Digital Image Processing (CSE/ECE 478)
Monsoon-2019
Assignment-3 (200 points)
Posted on: 30/08/19
Due on: 09/09/19

Grade Table (for teacher use only)

Question	Points	Score
1	30	
2	30	
3	20	
4	20	
5	15	
6	30	
7	30	
8	25	
Total:	200	

1. (30 points)
    1. Implement 1D Fast Fourier Transform (Recursive Formulation). (20 points)
    2. Use it to implement 2D FFT and display the result on suitable images of your choice. (10 points)
2. (30 points)
    1. Implement the Ideal, Butterworth and Gaussian Low Pass Filters and apply them on `lena.jpg`. (20 points)
    2. Using `lena.jpg`, apply the Gaussian low pass filter with two different values of σ. Compute the difference of the two outputs and display it. Report your observations.(10 points)
3. (20 points) Say you are travelling in a bus for a city tour in Paris and you want to capture the scene outside. Thankfully the Bus is stationary. Unfortunately, you can't open the window and the window acts as a semi-reflecting surface and the image contains reflections from inside the bus :(. But Hey, you got a camera which can focus on the outside scene by blurring the reflection off the window. This can be written as out1 = f1 + h2 * f2 where h2 is the blurring filter applied on f2. The second image is taken focusing the window surface, blurring the outside scene. This can be written as out2 = h1 * f1 + f2 where h1 is the blurring filter applied on f1. You are given the two images out1 and out2. Assuming you know h1 and h2, how would you find f1 and f2. Do you see any issues with the formula derived?

4. (20 points) Denoise the given image `land.png` and explain your process.

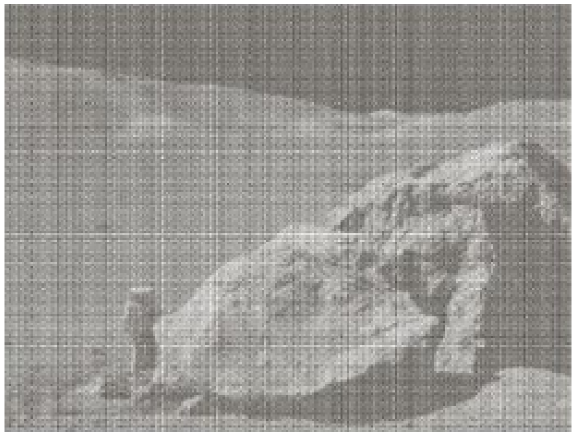

Figure 1: land.png

5. (15 points) Find the equivalent filter $H(u, v)$ in the frequency domain for the following spacial filter and show results of applying this filter on an image of your choice (in the frequency domain):

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Is $H(u, v)$ a low-pass filter or a high-pass filter? Show it mathematically.

6. (30 points)
    1. (15 points) Pick images f and h of different dimensions, each not necessarily square, and verify the convolution theorem ($DFT[f * h] = F_z H_z$, where F_z and H_z are the 2D-DFT of the images f_z, h_z, with f_z, h_z being the images f and h,with appropriate zero-padding).
    2. (15 points) In the above question, find the time required to compute the convolution directly (using `conv2`) and using the DFT (find F_e, H_e after zero-padding, multiply point-wise, and take inverse DFT). Use matlab functions (`tic, toc, cputime`) for calculating the time required for your operations. What are your observations for various different dimensions of f, h ?

7. (30 points) Aliasing can arise when you sample a continuous function or an image. The minimum sampling rate to avoid aliasing is called the nyquist rate.
    1. Sample this image at different spatial sampling frequencies n_x, n_y. Find the nyquist rate for the grayscale version of the image `bricks.jpg`.
    2. Investigate the effect of blurring the image on the nyquist rate.
       Show intermediate results wherever relevant.

8. (25 points)
   1. Compute the FFT of the image `rectangle.jpg`. Now rotate the image in spatial domain and compute the FFT of the rotated image. Report your observations and justify it mathematically. (10 points)
   2. Take the image `rectangle.jpg` and translate the image by few pixels Find the FFT of original and translated images. Report your observations and justify it mathematically. (15 points)